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PORTO RICO AGRICULTURAL EXPERIMENT STATION,
D. W. MAY, Special Agent in Charge.
Mayaguez, December, 1904.

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Bulletin No. 5.

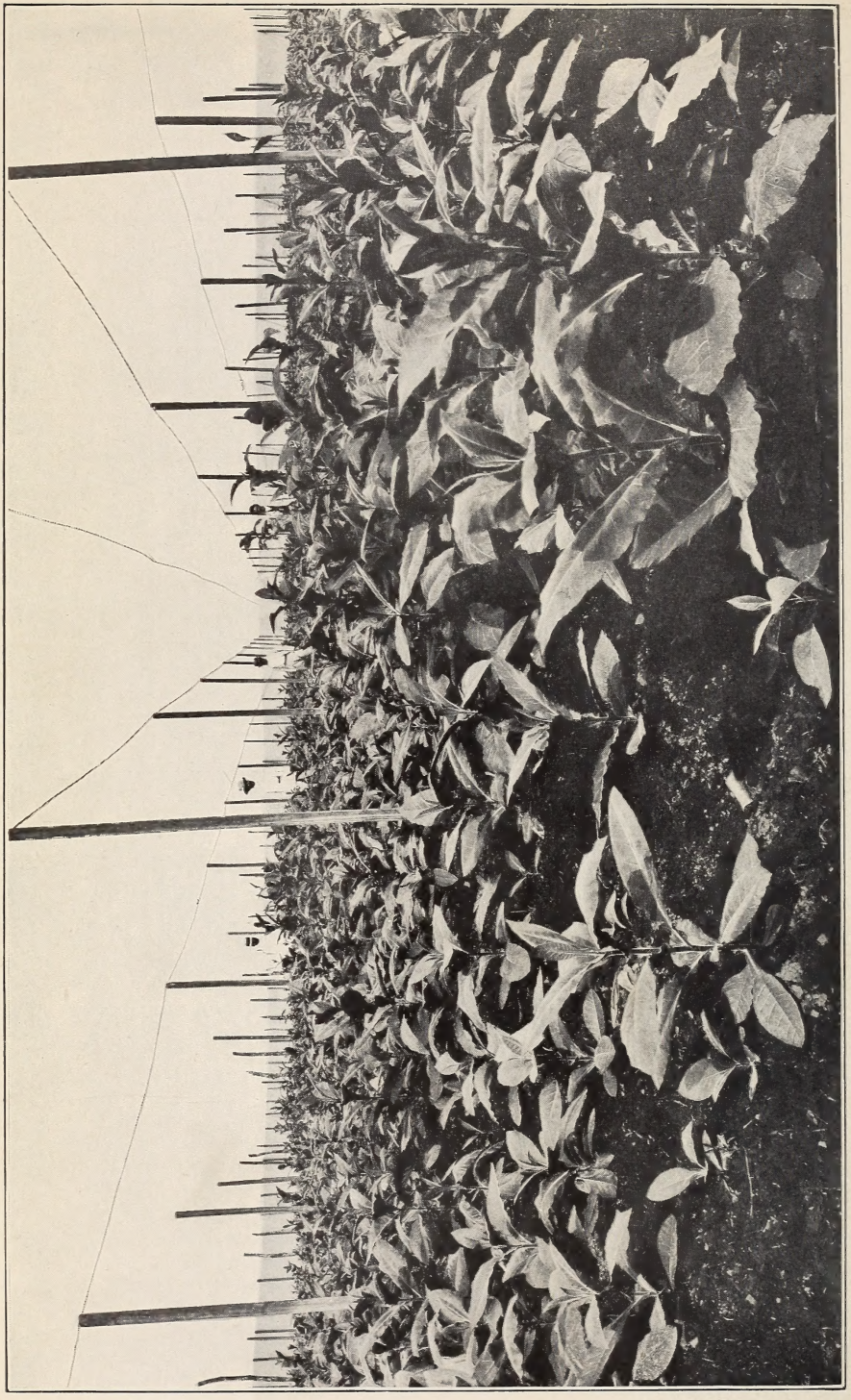
TOBACCO INVESTIGATIONS IN PORTO RICO DURING 1903-4.

BY

J. VAN LEENHOFF, JR.,
Tobacco Expert, Porto Rico Agricultural Experiment Station.

UNDER THE SUPERVISION OF
OFFICE OF EXPERIMENT STATIONS,
U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1905.



TOBACCO GROWING UNDER CLOTH SHADE, SHOWING VARIATION IN TYPES OF PLANT AND NECESSITY OF SELECTION.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,

D. W. MAY, Special Agent in Charge.

Mayaguez, December, 1904.

Bulletin No. 53.

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PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. True, Director of the Office of Experiment Stations, United States Department of Agriculture.]

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[a] Appointed tobacco expert in Bureau of Plant Industry of this Department July, 1904.

LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., December 5, 1904.

SIR: I have the honor to transmit herewith a manuscript by J. van Leenhoff, jr., on the results of tobacco investigations in Porto Rico during the fiscal year 1903–4, conducted under the direction of F. D. Gardner, former special agent in charge.

These results show that there is great need of improving the methods of growing and curing tobacco, and point out a number of changes which may be found advisable to adopt. By the introduction of up-to-date methods of growing and curing tobacco in Porto Rico it is believed that the business will be commercially successful where confined to suitable soil and climatic conditions. The area suitable for the enterprise is somewhat limited, but capable of considerable extension beyond that now cultivated to this crop.

Last year about 200 acres of tobacco was grown under cloth shade. The crop contained a high percentage of fine-appearing wrapper leaves, and the fact that the area will be extended to 300 or 350 acres during the next year indicates a belief that the enterprise will prove a financial success.

I respectfully recommend that this manuscript be translated into Spanish and published in both English and Spanish as Bulletin No. 5 of this station.

Respectfully,

D. W. MAY,
Special Agent in Charge.

Dr. A. C. TRUE,
Director Office of Experiment Stations,
U. S. Department of Agriculture, Washington, D. C.

Recommended for publication.
A. C. TRUE, *Director.*

Publication authorized.
JAMES WILSON,
Secretary of Agriculture.

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TOBACCO INVESTIGATIONS IN PORTO RICO, SEASON OF 1903–4.

INTRODUCTION.

Before undertaking any tobacco investigations the writer made a a reconnaisance of the principal tobacco-growing districts of Porto Rico and gathered from planters and manufacturers information relative to the methods employed in growing, curing, and fermenting tobacco. He visited the districts of Aibonito, Cayey, Cidra, Caguas, Aguas Buenas, Comerio, Arecibo, Utuado, Jayuya, and Yauco, spending several days in each. In each of these places careful inquiry was made as to the local methods used in growing tobacco. At the time of these visits most of the tobacco had been sold to the manufacturers, but wherever possible samples of it were examined with reference to its several classes and the quality of each. Typical samples were also secured from each district for further study, and most of them were made into cigars and tested with reference to their appearance, flavor, aroma, and burning qualities. Samples of typical soil and subsoil were also taken from each district for chemical and physical examination. The climatological conditions were also inquired into and a study made of the local weather records in order to better judge as to the best season for planting and especially for the curing of the tobacco. A brief report of these preliminary investigations follows.

METHODS NOW PRACTICED IN PORTO RICO.

METHODS OF PREPARING SEED BEDS.

In Porto Rico the tobacco seed bed is most frequently made on high inclined land, although it is sometimes made on level lands, called "vegas." The high lands are more exempt from the depredations of insects and especially from the "changa," or mole cricket, which burrows along beneath the surface of the ground and cuts off the plants.[a] On the hilly lands the preparation usually consists of burning over the ground and digging it up with a hoe. Some planters prefer stony lands for the seed beds, believing that they retain moisture best, although this is probably not the true cause of their value, as the stones would improve the drainage. If the land is not stony it is necessary to have good drainage, and this is affected by cutting small ditches at a distance of about 1 meter from each other and running directly down the hill. The tobacco seed is sown on the elevations between the ditches. If level land is chosen for the seed bed it is

[a] See Porto Rico Sta. Bul. 2.

first plowed and the grass allowed to rot, after which the surface is leveled and the weeds removed with a hoe preparatory to sowing seeds somewhat later. The time of preparing the seed beds ranges from August 1 in some districts to September 1 in others. As a rule the seeds are sown about the close of August, and a second sowing of seeds is made from eight to fifteen days later, in order to have later plants for replacing those that may die after the first planting in the field. The seed is simply scattered over the surface of the bed. The quantity of seed used varies in different districts, but is always very large. In from eight to twelve days after sowing the plants begin to show above ground and at this time the beds are carefully weeded. The work of weeding is generally done by women and children, who also go over the beds every day and search carefully for worms and insects, which they destroy. It requires from forty-five to sixty days for the plants to acquire size suitable to be transplanted to the fields, at which time they have about eight leaves.

FIELD PREPARATION AND PLANTING.

Plowing is commenced, if on level or very slightly rolling land, generally in August; but some planters begin to plow in July, using the American moldboard plow, if they possess such, which is very seldom the case. Often two or three neighbors combine to purchase one, thus saving a great deal in the cost to each. About a month after the date of the first plowing the land is gone over with the native wooden plow, which is much easier to handle. In October the land is plowed again, or gone over with a hoe. Some planters are now using the harrow (rastrillo).

As a rule the planting is begun early in November, although in some localities the plants are set out any time from the end of October until the end of February, as may best suit the convenience of the planter.

It is said that the early plantings produce a larger percentage of wrappers, on account of the plants not being troubled by insects biting holes, and the filler is milder. At Cayey the planters prefer to set their plants out late in November and early in December, as they claim that tobacco planted at this time has more aroma. As to the number of plants per acre in a field there is a wide divergence of opinion. Some of the planters in the Plata district set the plants 16 inches apart, with 24 to 26 inches between the rows. Others set them 12 inches apart, with 36 inches between the rows. Setting 18 inches from plant to plant and 36 inches between the rows is also practiced. Others again plant very irregularly, having no stated distance between the plants, in some cases filling the spaces between the plants with corn and beans. No instances are known where tobacco is planted with the special object of producing wrapper or filler. The usual method is to wait until the time of harvesting to classify the tobacco,

whether wrapper or filler, etc. If the soil is soft the transplanting is done by hand; but if it is hard, the work is generally done with a hoe or a big knife called a "machete." No care is taken to set the roots quite straight in the ground, and it has been observed that the tap root has been placed in the hole in such a way that it was completely doubled upon itself. The young plants are pulled out of the seed bed by hand, often without any rootlets and frequently with the tap roots broken off. In setting the seed plant they generally take it in the left hand, place the root in a horizontal position in a hole prepared by one stroke of a hoe, and then press a piece of hard earth on the roots, covering the hole with earth and leaving only a few of the leaves above the ground. Other planters set the plants too shallow, leaving the greater part of the stem of the plant exposed. Some planters make rows with a native wooden plow and set the young plants out in the ridges thus formed, while others, on the contrary, place them in the furrow made by the plow. Within fifteen or twenty days after transplanting the first cultivation or hoeing is undertaken, and from ten to fifteen days later a second hoeing is given, at each hoeing a little earth being thrown around each plant. If necessary the fields are hoed and weeded again, but usually this hoeing and weeding is done only twice. Cultivation and hoeing is generally done too deeply and too near the plant, no fear being felt of damaging the roots. It is believed that considerable damage results from the practice, owing to disturbing the plants' connection with the soil and destroying or injuring the feeding roots.

TOPPING.

Topping consists in pinching off the terminal bud and leaving the requisite number of leaves. This takes place from forty to sixty days after transplanting, and opinions differ greatly as to the number of leaves to remain on the plant. Some planters at Cayey leave from 8 to 20; at Caguas, from 15 to 20; at Utuado, from 12 to 16; at Jayuya, from 12 to 14; but a majority of the planters in all districts leave from 10 to 12 leaves and do their topping as soon as it is possible to pinch off the button flower. The object of low and early topping is to obtain larger and heavier leaves. The practice of low topping and late harvesting is attributable to the fact that during the Spanish régime, prior to 1898, the market demands were for a dark, heavy leaf containing a large amount of nicotin. The American market, which now uses most of Porto Rico's tobacco, demands a light, thin, mild leaf, and the system of topping and harvesting should be changed in order to meet the new demand. After topping, a great number of suckers appear on the plant, which are taken off usually at intervals of from four to eight days, until harvesting begins, which takes place from three to three and a half months after planting. After topping, many planters weed and cultivate again.

HARVESTING.

About thirty to forty days after topping the leaves begin to ripen, which is shown by their turning yellow. When this is observed the plants are cut close to the ground. This cutting is done almost everywhere when the plant is overripe. If the stalk is of a yellowish-brown or brownish-yellow color at the point of the cut the planter is assured that the crop is ready for harvest. Sunny or hot days are chosen for harvesting, as it is believed that the plants retain the gum better than on cloudy or cool days. After cutting, the plants are laid on the ground until wilted before being taken to the curing shed. They are transported from the field by taking a bunch in each hand (about five plants or more to each handful) or by binding a larger quantity on a pole, which is carried on the shoulder. Unless great care is taken in the cutting and carrying many leaves are torn, which diminishes the yield of wrappers. The plants are hung together the first day and then separated, each plant being hung singly. However, most planters hang them too close together, which is especially damaging when damp weather follows.

A few planters follow the Cuban system of harvesting, as they call it, which is as follows: When the yield of the so-called wrappers is large the leaves are cut from the top down in pairs and are hung across a man's arm. When ten or more pairs have been so placed they are slipped off on a pole of about 4 yards in length, which, as soon as filled, is taken to the curing shed.

After the tobacco is cut earth is thrown over the stubble in preparation for the second crop. Sometimes this process is repeated for a third crop, which is of a very inferior quality. For the second and third crop less care is taken than for the first.

DISEASES AND INSECTS.

Almost nothing is done in the way of protecting the young plants from insects and diseases peculiar to them, which are much the same as those which attack tobacco plants in the United States. The only method followed is to have women and children go over the plants in search of insects. To protect the young plants against the mole cricket (changa), which is especially destructive in loose soils, it is a common practice to wrap a leaf of the mamey or mango around the stem of the plant when it is set in the field, allowing the upper edge of the leaf to project a little above the ground. The use of Paris green, Bordeaux mixture, and other poisonous sprays in this connection is unknown.

CURING SHED.

After harvesting, the tobacco plants are taken to the curing shed to be cured and dried. The tobacco sheds in Porto Rico consist of wooden frames, with roofs of dried grass and sides covered with palm

leaves to shelter the tobacco from the elements. Many of them are from 36 to 120 feet in length. In general, no thought is given to ventilation or to the situation of the curing shed with reference to the sun, wind, and rain. Openings with shutters for regulating the inside conditions were not seen except in a single instance, which was on the plantation of a large American company. It may be said that the results of tobacco curing in Porto Rico depend exclusively upon the weather conditions. Nothing is done to prevent pole rot and drying out of the leaves before the color changes, so that good tobacco often loses its quality (elasticity, color, etc.) through bad treatment. Tobacco was seen hanging in stables, kitchens of houses, dwelling rooms, and sheds of which the sides were entirely open.

CURING AND FERMENTATION.

Many planters follow the practice of allowing twenty-one days for the curing of the tobacco. The plants are then placed in piles between green plantain leaves, without removing the leaves from the stalk, and allowed to remain from one to seven days, according to the locality and circumstances, with the object of producing the first fermentation and making the tobacco moist enough to strip. The leaves, after stripping or removal from the stalks, are separated into different classes, termed "capas," "tripas y capas," "tripas," and "boliches"—i. e., wrappers, fillers and wrappers, fillers, and the bottom or sand leaves. Sometimes these are again divided into first and second grades. They are then tied into bundles.

To ferment the tobacco some planters place it in this form in wooden cases, under heavy weights, for a period of about three months, after which a further classification is made, the leaves tied into hands, and baled. If the tobacco has been placed in the boxes in too moist a condition it very often rots; on the other hand, if it is too dry, it does not sweat enough, and consequently is of inferior quality. However, manufacturers work this unfermented stuff into their product, causing many of the cigars to have a green or acrid taste. Some planters make it a practice to open the cases and ventilate their tobacco once a month for a period of three months or even longer, in order, it is claimed, to obtain a better quality of leaf.

Other planters place the tobacco in sheds, hanging the plants from 4 to 5 inches apart, and allowing them to remain from twenty-two to forty days. The heavier plants are allowed to hang longer than those of a lighter weight. The leaves are then taken from the stalks without separating them into different grades, such as top, middle, and bottom leaves, excepting the "boliches," (the inferior damaged bottom leaves, which are kept separate). The leaves are then made into "hands" of about 80 to 100 leaves, and placed in round piles from 1½ to 2 yards in height and 2 yards in diameter. Green plantain leaves are placed under each pile and the whole covered with

them. The temperature is only ascertained by inserting the hand into the pile; if the pile becomes too heated it is taken apart, and after the tobacco has cooled off is remade. The pile generally remains in this condition from ten to twelve days, after which the tobacco is placed in wooden boxes for from fifteen to twenty days. When taken from the boxes it is graded into "capas," "tripas," and "capas y tripas," i. e., wrappers, fillers, and wrappers and fillers. After classification it is wrapped in green plantain leaves and again placed in boxes. If the tobacco is light, heavy weights are placed on it to help the process of fermentation. In from thirty to sixty days (about April or May, as the case may be) the tobacco is ready for use.

Other planters use about the same method, except that the heavier tobacco is placed in piles 5 meters long by 3 meters wide and $1\frac{1}{2}$ meters in height, while with the lighter grade tobacco the height of the piles is increased to 2 meters. In building the pile a hole for ventilation is left in the middle of it. The piles containing the heavier leaf necessarily contain much tobacco of lighter quality, and the reverse is true of the piles of lighter quality on account of the top, middle, and bottom leaves not having been kept separate. After from six to eight days these piles are torn apart and remade; this is repeated in about twenty days, the latter piles being allowed to stand until June or July. The tobacco is then classified as follows:

Classification of Porto Rican tobacco.

Light wrapper—Capa fina clara.
Dark wrapper—Capa oscura.
Light wrapper and filler—Tripa y capa clara.
Dark wrapper and filler—Tripa y capa oscura.
Heavy filler, first length—Tripa primera calidad.
Heavy filler, second length—Tripa segunda calidad.
Fine filler, first length—Tripa primera fina.
Fine filler, second length—Tripa segunda fina.
Ordinary—Tripa ordinaria.
Sand leaves—Boliches.

In another locality a pile was seen about 2 meters in height and 3 by 4 meters in diameter. This pile was allowed to remain until July. The tobacco was then moistened and classified. The outside leaves were quite "green" and the inside oversweated. Some parts of the pile were, more by accident than good management, cured just right.

Another method used by very few planters consists of making piles of from 2,000 to 5,000 pounds. After standing from six to eight days they are torn down and rebuilt. After another period of eight days these are again torn down and remade into piles of from 4,000 to 6,000 pounds each, which are allowed to stand one or two months. When the piles show signs of becoming too heated they are torn down and rebuilt. The tobacco is then baled, the bales containing all classes of

leaves. The classification is made by merchants after a further period of sweating extending over about a month, and is as follows:

Wrappers—First, second, and third sizes—light and dark.
Fillers—First, second, and third sizes—light and dark.

Some planters, endeavoring to secure light colors, make their fermenting piles long and very narrow—the width of only two hands—thus preventing as much as possible a rise in temperature. This method retains the light colors, but results in little or no fermentation, thus rendering the tobacco unsuitable for market on account of its green and bitter taste. Neither can it be safely put in the warehouse, because of its being unfermented.

SEED PRODUCTION.

In all cases tobacco seed is grown from the so-called sucker or second crop. No care whatever is taken of the seed plants, and all plants which flower, good as well as degenerated, are permitted to produce seed. When the seed capsules become dark brown they are cut from the plant and exposed for a day or more to the hot sun in order that they may become thoroughly dried. Such an irrational method of producing seed, with no attempt whatever at selection, is sufficient to explain why such large amounts of seed are required to produce a few good plants. A considerable part of such seed will not germinate, and of that capable of germination much is from degenerated plants and gives rise to seed plants having many undesirable qualities. It furthermore gives rise to many plants which lack in vigor and which may in part explain the fact that planters have to repeatedly reset plants in the field. As a result of this method of seed production one will find, upon inspection of the tobacco fields, leaves of all kinds, sizes, and shapes, many of which are undesirable for anything but filler purposes. (See frontispiece.)

IRRIGATION.

Irrigation is not practiced in tobacco culture in Porto Rico. Droughts frequently occur in Porto Rico which cut short the tobacco crop, and there is no doubt that where sufficient water can be secured irrigation of tobacco would prove profitable.

DRAINAGE.

Drainage is practiced in some localities by making ditches on the hilly lands above the tobacco, thus diverting the water and preventing an overflow of the fields. In the level lands the drainage methods as now practiced could be very much improved. In many parts of the island tobacco fields suffered severe losses during the season 1903–4 from standing water in the fields. Last year and the preceding one were quite dry, and tobacco crops suffered from drought. This

shows the necessity of providing both drainage and irrigation in order to fortify against unfavorable climatic conditions.

TEXTURE OF TOBACCO SOILS.

Samples of soils and subsoils were taken from nearly every district visited, and a portion of these were transmitted to the Bureau of Soils, United States Department of Agriculture, for mechanical analyses. The following table gives the results of the analyses, and indebtedness to the Bureau of Soils is hereby acknowledged for its assistance in this matter:

Mechanical analyses of soils and subsoils from typical tobacco fields in several of the principal tobacco-growing districts of Porto Rico.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
9372	(1) 8 kilometers NW. of Aibonito.	Valley "La Plata," soil, 0–10 inches.	5.97	3.24	6.02	4.20	12.64	10.04	31.72	31.98
9373	(2) 8 kilometers NW. of Aibonito.	Valley "La Plata," soil, 0–12 inches.	3.75	6.68	7.28	2.72	4.94	7.20	37.28	33.70
9374	(3) 3–4 kilometers SE. of Cayey.	Gravelly sandy loam, 0–10 inches.	4.35	10.86	12.82	5.68	10.18	7.96	25.82	26.68
9375	(4) 3–4 kilometers SE. of Cayey.	Brown stony loam, 10–20 inches.	2.37	6.06	10.24	4.50	7.80	9.88	31.84	29.54
9376	(5) 3–4 kilometers SE. of Cayey.	Brown sandy soil, 0–12 inches.	1.33	.52	3.16	3.62	15.14	18.02	33.36	26.18
9377	(6) 3–4 kilometers SE. of Cayey.	Subsoil of 9376, 12–20 inches.	.78	.84	4.30	4.32	15.22	17.80	32.38	25.14
9378	(7) 3 kilometers SW. of Cidra.	Dark sandy loam, 0–12 inches.	1.85	1.72	4.70	3.60	11.18	8.94	38.50	31.20
9379	(8) 3 kilometers NE. of Comerio.	Dark sandy loam, 0–12 inches.	2.53	4.98	9.10	5.20	11.46	8.36	32.96	27.66
9380	(9) 4 miles SE. of Caguas.	Brown sandy loam, 0–10 inches.	1.44	5.30	8.26	5.22	11.10	11.32	32.40	25.80
9381	(10) 4 miles SE. of Caguas.	Subsoil of 9380, 10–20 inches.	1.36	5.80	6.54	4.28	10.12	10.40	33.54	28.96
9382	(11) Caguas	Brown sandy loam, 0–10 inches.	1.29	6.22	14.98	9.50	21.92	17.50	15.36	14.34
9383	(12) Caguas	Subsoil of 9383, 10–20 inches.	.82	2.42	5.96	3.50	8.02	10.76	42.64	26.70
9384	(13) 2–3 kilometers E. of Aguas Buenas.	Dark loam, 0–10 inches.	2.11	3.68	7.16	4.42	8.62	8.46	41.62	25.98
9385	(14) 2–3 kilometers E. of Aguas Buenas.	Yellow loam, 10–20 inches.	1.07	1.80	4.90	4.24	10.28	9.80	43.24	25.74
9386	(15) 2–3 kilometers E. of Aguas Buenas.	Yellow loam, 10–20 inches.	1.25	3.20	6.36	4.06	7.76	8.96	44.90	24.68
9387	(16) 4–5 kilometers E. of Arecibo.	Fine sand, 0–12 inches.	.59	.04	.50	4.32	53.32	22.94	11.72	6.98
9388	(17) Jayuya	Sandy loam, 0–10 inches.	3.19	3.16	5.30	3.04	7.46	9.52	45.82	25.56
9389	(18) 1 kilometer from Jayuya.	Sandy loam, 0–10 inches.	2.08	7.22	16.60	8.48	17.60	11.14	15.10	23.58

An inspection of the samples at the time they were taken showed that, as a rule, the texture was too heavy, as compared with the standard of typical tobacco soils in the United States, for the production of high-grade cigar tobacco and cigar wrappers. A study of the above table brings out this fact even more strongly than did the mere inspection. It will be seen that, with but two exceptions, the percentages of clay and silt are quite high.

Under the old régime of tobacco production in Porto Rico, the fact that the tobaccos produced were as a rule rather coarse, dark in color, and too heavy to meet the market demands in the United States, is attributable largely to the heavy texture of the soil.

The sample of soil from Caguas shows about half as much silt and clay combined as those from most of the other districts, and it was observed that in this district as a rule the tobacco is lighter in structure, texture, and color than in the other districts. This tobacco, however, is inferior in flavor and aroma to that from Cayey and Comerio, and it is therefore thought that the district might be largely devoted to the production of a wrapper and binder leaf. By improved methods of topping, harvesting, curing, and fermenting it is believed that this could be accomplished in the Caguas district, even without the use of shade.

The Arecibo soil, which contains a comparatively low percentage of silt and clay, has a texture which would designate it as an excellent tobacco soil, especially for the production of a wrapper leaf. As a matter of fact, the tobacco from this district has no aroma, a poor taste, and does not burn so well. This poor quality is probably attributable to the fact that the district is located near the seacoast and swept during the greater part of the time by the trade winds, and also that the soil contains very little organic matter, which it would be important to increase by the use of green manures.

The trade winds coming from across the ocean are laden with moisture containing traces of chlorin, which in time possibly causes an increase in the chlorin content of the soil. It is well known that the presence of very small amounts of this element has a detrimental effect on the burning qualities of the tobacco.

Experiments at Aibonito on soils that contained 31.98 and 33.70 per cent of clay have shown that it is possible, through the shading of the tobacco with cheese cloth and by the application of improved methods of harvesting, curing, and fermenting, to produce tobacco yielding a high percentage of excellent wrapper leaves, possessing the qualities of fair combustibility, good elasticity, uniform color, etc.

It was noticed in the first experiments, however, that some of the leaves of this tobacco were too thin and would not keep long in the warehouse without more or less deterioration. The veins of the leaf in this case were rather too heavy, especially in those leaves with

very thin body, and consequently were too prominent when wrapped in cigars.

It thus becomes very desirable to breed a special type of wrapper leaf for shade growing and outside growing, and also a special type of filler tobacco. Such types would undoubtedly greatly increase the value of the Porto Rico tobacco crop.

EXPERIMENTS IN GROWING, CURING, AND FERMENTING TOBACCO.

As a result of the above-described preliminary investigations it was concluded that Porto Rico presents very favorable conditions for the production of considerable high-grade tobacco, but that the extension of such a business would necessarily be confined to suitable soil areas and favorable climatic environments. The investigations also show that for the most part the methods employed by the planters are primitive, and that there is great need of their adopting more up-to-date methods. It was decided, therefore, to undertake experiments with growing, curing, and fermenting tobacco.

Owing to the limited funds available for this work it was necessary to arrange for cooperation with an interested tobacco grower. Such an arrangement was entered into with a planter near Aguas Buenas, the latter giving the use of land, labor, buildings, and material, in so far as it did not interfere with his regular business. The facilities offered by the equipment of the ordinary planters are, at the best, in many ways unsatisfactory for experimental purposes, and because the funds available would not permit the necessary modification of these conditions some of the experiments undertaken failed. A report of such of the work as is of value follows:

SEED-BED EXPERIMENTS.

Several seed beds were made, each 3.5 feet wide by 18 feet long. The earth was raised a few inches above the general level in bed form, and the sides of the beds supported by old boards or poles. One half of the beds was shaded by a removable straw shade and the other half remained without shade. The shade was supported on poles about 4 feet above the beds. (Pl. I, figs. 1 and 2.)

Imported Habana, Connecticut Habana, Florida Sumatra, imported Sumatra, and Porto Rico seed were sown, each in a separate bed, half with shade and half without. The records show that the seeds in the shaded portion of the beds came up from two to four days earlier than those in the unshaded portion.

After the plants were all well up the straw shades were removed for a short time each day early in the morning and late in the afternoon. The time of exposure was gradually increased, and eventually the plants were shaded only from 10 a. m. to 3 p. m. A few days before transplanting to the fields the shade was removed and the plants exposed throughout the day in order to toughen them and

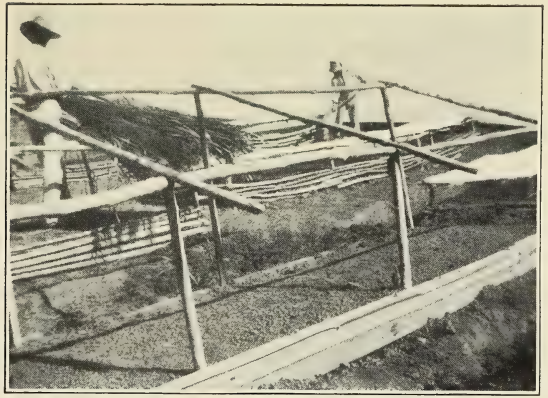

FIG. 1.—CONSTRUCTING STRAW SHADE FOR SEED BEDS.

FIG. 3.—TOBACCO SEED BEDS PROTECTED BY CLOTH COVERING.

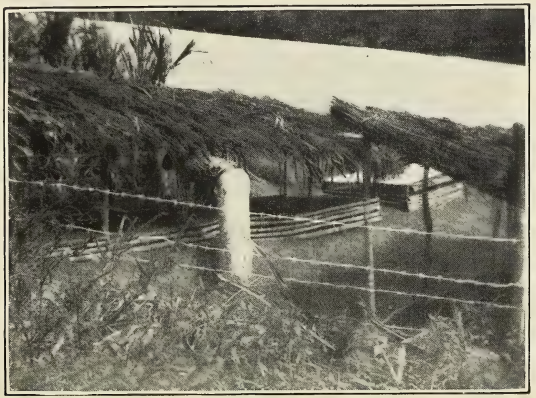

FIG. 2.—TOBACCO SEED BEDS PROTECTED WITH STRAW SHADE.

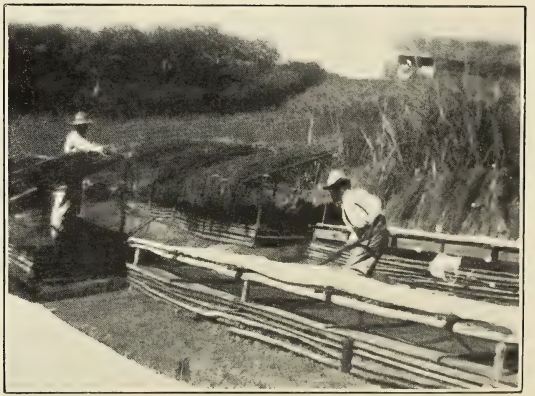

FIG. 4.—CLOTH AND STRAW COVERED SEED BEDS.

better enable them to stand the sun when transplanted. It was observed that while the plants in the shaded portion of the beds came up earlier and looked healthier during the first three weeks, after that time those without shade looked the better and were finally more vigorous and larger.

The advantage of the shade is in reducing evaporation and thus enabling the seeds to germinate quicker and more perfectly, and also that it protects the beds from washing by heavy rains. It often happens, as it did in 1903, that many seed beds are entirely destroyed by heavy rains, either by washing away the seeds before they germinated or by washing out the plants when quite small.

Cloth shade was also tried, and seemed to serve better than the straw (Pl. I, figs. 3 and 4). The cloth shade was less dense than that of straw, and, while it allowed most of the rain to pass through, it served as a regulator by breaking the fall of the rain and thus preventing washing.

It is believed that straw shading offers sufficient protection against washing of the seed beds alone to justify its construction, and that in practice it would be well to dispense with it as soon as the plants are well established and all danger from washing is past.

Another seed bed was divided into five plats and each covered with a different colored cloth, the colors being white, green, blue, yellow, and red. Experiments in France on lettuce and other plants, when growing under different colored glass, have shown that plants develop very differently as a result of such treatment, and it was thought that this experiment might indicate something of value in relation to the growing of wrapper leaf under cloth. Unfortunately the seed used on these plats was poor, being imported Cuban seed, which seems to be very unreliable if bought in the open market, and only a few plants were secured, so that no data of any importance were obtained.

Soon after the tobacco plants in the seed beds had come up numerous burrows were noticed, which indicated the presence of "changas." These galleries or burrows were treated with a solution consisting of 1 part of kerosene to 14 parts of water. Openings were made in the burrows at frequent intervals and a small amount of the solution put in. This treatment was repeated two days later, after which no plants were destroyed.

The plants also appeared to be suffering from some disease and were therefore sprayed with a dilute solution of Bordeaux mixture. This treatment seemed to be very beneficial, and after a few days no more diseased plants appeared. Bordeaux mixture is especially valuable as a seed-bed spray because it is a remedy for many diseases that occur on young tobacco plants.[a] When the plants turn yellow in

[a] A description of the flea beetle, tobacco worm, leaf miner, cutworm, and other insects affecting tobacco, together with remedies for their extermination, is given in Farmers' Bulletin No. 120, U. S. Department of Agriculture. See also, Porto Rico Sta. Bul. 2 on the Changa or Mole Cricket.

color it indicates that the soil is too wet or that there is a lack of plant food. In the former case better drainage should be provided. By elevating the seed beds, as above described, there is no trouble from excess of water. When there is a lack of plant food it is well to apply an extract of barnyard manure or cotton-seed meal. This may be applied as a spray, using care to not get the solution sufficiently concentrated to burn the plants.

TRANSPLANTING.

Experiments in methods of transplanting were made both outside and under cover. A comparison was made outside between plants partially shaded during the first ten days after planting and those with no shade. For shading, mamey and mango leaves, both everywhere common in Porto Rico, were used. A leaf was placed 1 to 2 inches south of each tobacco plant, and by inserting the petiole in the ground and inclining the top of the leaf toward the plant, this shielded it from the direct rays of the sun during the hottest part of the day. Five rows of 89 plants each, or 445 plants, were protected with shade, and an equal number of rows and plants adjacent were planted at the same time without shade. Of the protected plants 125 died and were replanted, and of the unprotected 300 died and were replanted. At the time of harvesting the protected plants showed much greater uniformity in growth than the unprotected ones.

In Deli, Sumatra, it is a common practice to shade the plants by the use of small, thin, paddle-shaped boards, the small end being stuck into the ground to keep them in proper position. Such small boards will last for a long time and may be repeatedly used year after year. By reducing the numbers of plants necessary to reset, the crop is made more uniform, easier to harvest, and of greater value. It is believed, therefore, that this simple method of shading the young plants is practicable in Porto Rico, especially so if planting is to be done during periods when dry weather and sunshine prevail.

A trial was also made to ascertain the effect of mamey leaves as a protection against cutworms and mole crickets. Of 300 plants wrapped in mamey leaves 200 died and had to be replanted, and of the same number unprotected 220 died. The mamey leaves were formed into cylinders, with the edges slightly overlapping, and placed in the ground with the roots and stem of the plants inside. Care should be taken to place the leaf no deeper in the soil than is necessary to prevent the crickets from burrowing beneath. While the mamey leaves make successful barriers against the crickets they are probably somewhat detrimental to the early growth of the plants, because they confine the upper roots of the plant, and also because water from rains collects within the leaf and escapes very slowly, thus sometimes injuring the plants. In both of the above experiments the planting

FIG. 1.—SHADE-GROWN TOBACCO AT AIBONITO SOON AFTER PLANTING.

FIG. 2.—IRREGULAR SIZE, DUE TO REPLANTING.

FIG. 3.—BADLY FORMED LEAVES FOR WRAPPERS.

FIG. 4.—GOOD, UNIFORM SHADE-GROWN TOBACCO SIXTY DAYS AFTER PLANTING.

was done by native workmen and in their usual manner. The plants were from unselected native seed and showed considerable variation in size and vigor. It is due chiefly to these two factors that so large a number of the plants in all cases failed to survive the process of transplanting.

Under the cheese cloth another experiment was tried to ascertain the effect of better planting. On one plat 1,700 plants were carefully set out, the roots being placed straight in the holes, and moist earth in all cases pressed firmly around them. The following day each plant was watered. Another plat of 800 plants was planted in the usual native way. The results of careful planting were very marked, only about 5 per cent of the plants being lost, while with those planted in the usual manner the loss was much greater. The natural conditions, however, were more favorable to those which were carefully planted, so that a fair comparison could not be made.

There is no doubt that by a careful selection of seed from hardy plants, and by using only that portion of it which has good vitality, plants will be produced that will stand the process of transplanting with much less loss, and that this loss can be still further reduced by better methods of transplanting, such as shading the young plants from the sun, protecting them from cutworms and mole crickets, and by carefully placing the roots in the soil and watering when dry. By avoiding as much as possible the replanting of the fields the crop is made more uniform, easier to harvest, and more valuable. (Pl. II.)

VALUE OF SHADE FOR PRODUCING WRAPPERS.

It was planned to make a careful comparison of the cost of production and value of shade-grown tobacco with that grown outside, but under otherwise similar conditions.

Four-elevenths of an acre was planted under shade November 21, 1903, and at about the same date 2 acres were planted outside. Very heavy rains occurred just after planting that outside, and a large part of the first planting was washed out. The delay in replanting and other uncontrollable factors interfered to such an extent with the outside crop that it was not worth while to carry out the comparison. The shade-grown tobacco was carried through to the finish and a careful record kept of it. Owing to delay in getting a curing shed ready for this tobacco it was harvested in an overripe condition, and for this reason many of the bottom leaves were lost. A short time before the leaves began to ripen a disease appeared on them, which gave rise to numerous whitish and brown spots. It spread very rapidly, and at the time of harvesting nearly all leaves were affected and many of them so badly damaged as to make them useless for wrappers.

Some of the diseased leaves were sent to the United States Depart-

ment of Agriculture for examination, and the Pathologist reported as follows:

The leaves all appear badly infected with fungus *Ascochyta nicotianæ*. To the best of my information this fungus has not as yet been found within the limits of the United States proper, and we have never heard of its previous occurrence in Porto Rico. In past years several reports of its occurrence have been made from various points in Italy. These reports, however, have been very meager, and we know very little concerning its destructive nature and practically nothing concerning the methods of control. Judging from the specimens of leaves submitted, it would appear to be a rather serious disease, and great care should be taken to prevent its spreading into other places.

It is quite possible that judicious fertilizing would increase the vigor of the plants and render them less susceptible to the disease. The use of a fertilizer containing a rather large percentage of potash, and, if the soil is soggy, careful attention to drainage, might be beneficial. Diseased leaves and all refuse from a diseased crop must be burned.

Some of the results obtained in the experiments are summarized as follows:

Results of harvesting 5,300 plants, or four-elevenths of an acre, of shade-grown tobacco.[a]

	Pounds.
Weight of cured leaves	330
Weight of fermented leaves	287
Loss in fermenting	43
Wrappers:	
Dark	26
Medium	44
Fine	42
Total	112
Small, medium and fine	5
Partly spotted, medium and fine	7.5
Resago, medium and fine	57.5
Quebrado	31
Total	101
Fillers:	
Light	43
Heavy	31
Total	74
Yield of four-elevenths of an acre	287
Yield per acre	789

[a] It should be remembered that this was a diseased crop and not a fair example.

Value of the crop by classes and cost of production.

26 pounds wrappers, dark, at $100 per 100 pounds	$26.00
44 pounds wrappers, medium, at $250 per 100 pounds	110.00
42 pounds wrappers, fine, at $250 per 100 pounds	105.00
5 pounds wrappers, small, at $35 per 100 pounds	1.75
7½ pounds wrappers, partly spotted, at $75 per 100 pounds	5.63
57½ pounds wrappers, resago, medium and fine,[a] at $60 per 100 pounds	34.50
31 pounds wrappers, quebrado, medium and fine,[b] at $16 per 100 pounds	5.56
43 pounds filler, light, at $9 per 100 pounds	3.87
31 pounds filler, heavy, at $12 per 100 pounds	3.72
Total	296.03
Approximate cost of production [c]	250.00
Net profit	46.03

In the above statement the values were placed on the various grades by the planter with whom cooperation was carried on and who is also a manufacturer of cigars.

The statement shows that there was a shrinkage in weight of 13 per cent during fermenting and that, notwithstanding the very unfavorable conditions, there was a net profit of about $46 on the four-elevenths of an acre of shade-grown tobacco, or $126 per acre.

The greater part of the so-called "resago" and "quebrado," as well as part of the filler, would have been classed as good wrappers if it had not been damaged by disease. The large and numerous spots on the leaves reduced their elasticity and made them easily torn, so that they could not be used as wrappers.

During the season of 1902–3 the writer planted a small area of tobacco under shade in the vicinity of Jayuya. The plants were set in rows 3 feet apart and 1 foot apart in the row, there being 2,200 plants on approximately two-thirteenths of an acre. After curing, this tobacco was fermented in the warehouse of a tobacco company at Aibonito, and was sorted and graded by the company in their customary manner. The results were as follows:

Yield of shade-grown tobacco of different grades.

	Pounds.
Light red wrappers	25
Light green wrappers	18
Medium red wrappers	26
Medium green wrappers	65
Dark wrappers	30
Sumatra wrappers	7
Total	171

[a] Spotted leaves, part of which can be used for wrappers.
[b] Leaves most of which can be used for binder and filler.
[c] Includes all expenses on the established tobacco farm.

	Pounds.
Tripa capa clara	14
Tripa capa negra	22
Total	36
Tripa	21
Yield of two-thirteenths of an acre	228
Yield per acre	1,482

Samples of the light and medium wrappers were valued by cigar factories in San Juan at $2.50 and $2, respectively, and one large factory offered $1.50 a pound average.

As a result of these experiments and observations in regard to larger areas that have been grown under shade in Porto Rico it may safely be said that shading increases the yield, quality, and percentage of wrappers sufficiently to make shading a profitable business, providing it is practiced only on soils suitable for growing wrappers and the crop is given the best of care throughout its growth and further treatment in curing and fermentation.

EXPERIMENTS WITH FERTILIZERS.

It was planned to try the effect of fertilizers at both Aguas Buenas and Aibonito, but uncontrollable circumstances prevented the work at the first-named place. At Aibonito, however, seven $\frac{1}{10}$-acre plats were laid out and treated as follows:

Plan of fertilizer experiments.

Plat No. 1.—No fertilizers.
Plat No. 2.—20 pounds sulphate of potash, 60 pounds acid phosphate.
Plat No. 3.—20 pounds sulphate of potash, 20 pounds nitrate of soda.
Plat No. 4.—60 pounds acid phosphate, 20 pounds nitrate of soda.
Plat No. 5.—60 pounds acid phosphate, 20 pounds sulphate of potash, and 20 pounds nitrate of soda.
Plat No. 6.—60 pounds acid phosphate, 20 pounds sulphate of potash, 20 pounds nitrate of soda, and 200 pounds lime.
Plat No. 7.—No fertilizers.

The plats were all planted on the same day, and at a later date each plat was photographed for the purpose of recording the differences in growth, which in some cases was very marked. Even the least affected of the treated plats showed a small increase in growth over the untreated. By comparison, plats 2 and 4 were found to be equally good, but much superior to No. 1, which had no fertilizer. No. 3 was much inferior to Nos. 2 and 4, but slightly better than No. 1. This showed that the sulphate of potash and nitrate of soda combined had very little effect, and that acid phosphate when combined with either of the others separately gave a marked effect. It seems, therefore, that for growing tobacco on this soil acid phosphate as a manure is

FIG. 1.—PLAT 1, NO FERTILIZER.

FIG. 3.—PLAT 3, SULPHATE OF POTASH AND NITRATE OF SODA.

FIG. 2.—PLAT 2, SULPHATE OF POTASH AND ACID PHOSPHATE.

FIG. 4.—PLAT 4, ACID PHOSPHATE AND NITRATE OF SODA.

FIG. 1.—PLAT 5, ACID PHOSPHATE, SULPHATE OF POTASH, AND NITRATE OF SODA.

FIG. 2.—PLAT 6, ACID PHOSPHATE, SULPHATE OF POTASH, NITATE OF SODA, AND LIME.

FIG. 3.—A GOOD FIELD OF TOBACCO NEAR AGUAS BUENAS.

FIG. 4.—DESTRUCTIVE WORK OF TOBACCO SPLIT WORM.

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far more efficient than sulphate of potash and nitrate of soda combined. This conclusion is further emphasized by comparing plats 3 and 5, the latter having acid phosphate in addition to the sulphate of potash and nitrate of soda, which No. 3 has, and showing a very marked increase in growth over No. 3. Since plat No. 5 is very little better than Nos. 2 and 4, it further emphasizes the conclusion arrived at by comparing Nos. 1 and 3—i. e., that nitrate of soda and sulphate of potash have had very little effect on the growth of tobacco on this soil. Plat No. 6, to which 200 pounds of lime was added, showed no improvement over No. 5, which was otherwise treated the same. (Pl. III, figs. 1 to 4; Pl. IV, figs. 1 and 2.) It was hoped that further valuable results would be obtained by keeping each plant separate through the harvesting, curing, and fermenting, thus obtaining the effect of the different fertilizers upon the actual yield and quality of tobacco. It was not possible, however, to carry out the last part of the experiment.

So far as the experiment was carried it indicates that the appropriate fertilizer for tobacco on this field is one containing a large amount of acid phosphate and smaller amounts of nitrogen and potash.

The experiment is an example of what any planter can easily try for himself, and as the question is put to the soil of his own estate and the answer given in the effect upon the crop he is growing, the result can not fail to be far more satisfactory than any chemical examination that could be made. It should also be recognized that what may give excellent results on one soil may fail altogether on another.

The writer had under observation another field, part of which was treated with cotton-seed meal at the rate of 2,000 pounds per acre, and another part given a liberal dressing of compost containing horse manure, vegetable matter, and tobacco stems. The compost was applied about three weeks before planting and the cotton-seed meal the day before planting. The plants given cotton-seed meal grew more rapidly, especially during their early life. It is probable that the ingredients of the cotton-seed meal were immediately available, and in case of the compost, which was not well decomposed, they were not.

The application of fertilizers is a question which has received very little consideration in Porto Rico, but it is an important one, especially in relation to tobacco growing. It may be pardonable, therefore, to quote briefly from other sources.

According to analyses reported by R. J. Davidson, of the Virginia Agricultural Experiment Station, the entire plants of a tobacco crop yielding 1,000 pounds of leaves per acre contain 66.85 pounds of nitrogen, 8.68 pounds of phosphoric acid, and 85.41 pounds of potash. The leaves of such a crop contain 44 pounds of nitrogen, 5.89 pounds of phosphoric acid, and 58.19 pounds of potash. The parts usually

removed from the soil, the leaves and stalks, contain 58.9 pounds of nitrogen, 7.72 pounds of phosphoric acid, and 77.86 pounds of potash.[a]

This shows that the larger part of the fertilizing constituents is found in the leaves and stalks, and emphasizes the exacting character of the demands of the tobacco plant on the soil and the importance of returning to the soil all of the stalks and roots.

In several places it was noticed that planters in preparing tobacco ground for a future crop had thrown out of the field all of the roots and stalks of the tobacco, a practice that would not have been permitted had the planters appreciated their value. It was also noticed that beans were harvested by cutting and removing the whole plants from the field. As this crop belongs to the leguminous family, and through the agency of the tubercles on its roots has the power to utilize free nitrogen from the air, thus becoming itself rich in this element, the vines and all unused parts of the plants should be returned to the soil.

Manure in the form of well decomposed compost is excellent for tobacco and one which can easily be supplied in considerable quantity in Porto Rico. Any plant débris, such as banana stalks, weeds, and grass may be used, and should be supplemented as far as possible by animal manures and animal débris. Horse manure is the most valuable and cattle manure ranks next. It is said that goat and pig manure gives the tobacco a bad taste, while sheep manure produces a heavy leaf. These should therefore be avoided. It is important that the compost be well decomposed; if not, its application may become harmful. An application may consist of 5 to 20 tons per acre, according to the requirements of the soil and the concentration of the compost.

Green manures, i. e., the plowing under of leguminous crops, such as cowpeas or velvet beans, often give good results and increase the thinness and elasticity of the tobacco leaves.

Guano, which occurs in many caves in Porto Rico, is also a valuable manure. Its composition varies greatly, and the requisite amount to use can only be determined by experiment.

Commercial fertilizers should be used with great care. The use of potash improves the combustibility of tobacco, but it should be used only in the form of a sulphate, carbonate, or nitrate. Muriate of potash should never be used, as the chlorin is considered very harmful. Cotton-seed-hull ashes is also a most valuable source of potash. Phosphoric acid should not be used in excess, for, according to Nessler, the more there is in the soil the more the plant takes up, and too much affects the color of the ash. Acid phosphate and phosphatic slag are used in preference to bone phosphate, on account of being immediately available. Nitrogenous manures should be used with moderation. According to Schloesing, they increase the vigor of the

[a] Virginia Sta. Buls. 14 and 50.

plant, but have a marked effect upon the nicotin, increasing it to an extent that is injurious. In France the planters are advised by the tobacco service not to use nitrate of soda, as it seems to produce tobacco without quality and causes fizzing. Cotton-seed meal has also proved in Porto Rico to be a very good source of nitrogen for tobacco raising, and its cost is rather moderate. Cotton-seed meal not only contains nitrogen, but also a small amount of phosphoric acid and potash. On heavy soils or those deficient in organic matter a small application of lime often gives excellent results.

EXPERIMENTS IN CURING TOBACCO.

The curing experiments were conducted in three curing sheds:

First. A frame building, formerly constructed for a storehouse and part of which was used in that capacity during the curing experiment. As the large doors were frequently opened in order to enter the building, it materially interfered with the attempt to control the condition for the curing of tobacco. The building was modified by arranging small hinged doors on opposite sides just above the floor and just below the roof.

Second. A shed was constructed of poles and canvas and covered by a straw roof. The canvas was treated with linseed oil in order to keep out the humidity and painted black so as to darken the interior. The black surface, however, absorbed the sun's heat and readily transmitted it to the air within, thus causing the temperature to become too high. This effect was early noticed and rectified by putting a white canvas over the black one, thus reflecting the sun's rays and keeping the interior of the shed cooler.

Third. A large shed was constructed of board sides and a thatched roof supported by a pole framework. Large hinged doors were made in the sides for ventilation.

The daily temperature and relative humidity was ascertained in each shed from March 19 to April 23, with the results given in the following table:

Temperature and relative humidity in three curing sheds, taken daily at 3 p. m.

Date.	Large shed.		Cloth-covered shed.		Frame shed.	
	Temperature.	Relative humidity.	Temperature.	Relative humidity.	Temperature.	Relative humidity.
1904.	° *F.*	*Per cent.*	° *F.*	*Per cent.*	° *F.*	*Per cent.*
March 19	76.5	74.0	80.0	61.0	82.0	65.0
March 21	76.0	76.0	79.0	60.0	81.0	63.0
March 22	70.0	90.0	71.5	83.5	74.5	78 0
March 23	74.0	82.0	76.0	72.0	78.0	79.0
March 24	76.0	82.0	76.0	77.0	77.0	83.0
March 25	74.0	80.0	74.5	78.0	77.0	77.0
March 26	78.0	71.0	78.0	65.5	79.0	69.0
March 28	74.0	86.0	74.0	82.0	74.0	84.0
March 29	78.0	75.0	78.0	69.0	79.0	71.0
March 30	74.0	86.0	73.5	88.5	74.0	78.0
April 4	79.5	64.0	80.5	61.0	85.0	62.5
April 5	82.0	51.0	83.5	82.0	84.5	57.5
April 6	72.0	91.0	71.0	90.0	74.0	82.0

Temperature and relative humidity in three curing sheds, etc.—Continued.

Date.	Large shed.		Cloth-covered shed.		Frame shed.	
	Temperature.	Relative humidity.	Temperature.	Relative humidity.	Temperature.	Relative humidity.
1904.	° *F.*	*Per cent.*	° *F.*	*Per cent.*	° *F.*	*Per cent.*
April 7	80.0	75.0	79.5	77.0	71.5	70.5
April 8	77.5	77.0	76.0	78.0	79.0	71.0
April 9	80.0	72.0	80.0	68.0	82.0	65.0
April 11	82.0	58.0	80.5	64.0	85.0	56.5
April 12	76.0	70.0	76.0	66.0	78.0	79.0
April 13	75.5	80.0	75.5	74.0	79.0	68.0
April 14	81.0	75.5	81.0	66.0	84.0	62.0
April 15	82.0	65.0	80.5	62.0	83.0	57.0
April 16	81.5	63.0	80.5	64.0	82.0	58.0
April 18	80.0	68.0	80.5	66.0	81.0	63.0
April 19	79.0	73.0	79.5	69.5	81.0	68.5
April 20	80.0	70.0	82.0	56.5	83.0	72.5
April 21	78.5	63.5	80.0	62.0	81.0	56.0
April 22	79.0	71.0	81.5	61.0	82.5	60.0
April 23	79.0	71.0	83.0	57.0	85.0	56.5
Average	77.67	73.57	78.26	70.01	80.21	68.3

Briefly, the results show that in the frame building with a mean temperature of 80.2° F. and relative humidity of 68.3 per cent, the tobacco dried too quickly and the leaves when cured contained many green spots. In the cloth shed prior to putting on the white outside canvas the temperature was very much too high and the tobacco was badly damaged. After modification the mean temperature was 78.26° and the relative humidity 70 per cent, and the conditions as shown by the tobacco were more favorable than in the frame building. In the large shed the mean temperature was 77.67° and the relative humidity 73.57 per cent. The tobacco in this shed was better cured than in either of the others, and would indicate that the slightly lower temperature and higher relative humidity were favorable to the best results.

FERMENTATION.

The experimental crop of shade-grown tobacco was too small in amount to make it possible to carry on a satisfactory fermenting experiment with it. It was therefore combined with other tobacco from the plantation and fermented. The writer gave personal supervision to the fermentation of all the tobacco of the plantation and kept records of the temperature in the several fermenting piles, having the piles torn down and rebuilt whenever the temperature reached an elevation which indicated the necessity of this operation. Below is given the temperature records of one pile, the tobacco of which was grown outside and contained a high percentage of wrapper leaves. The fermentation investigations were carried on in a stone building of which two sides each had a window and a door that were not provided with means of being closed. These openings, through which the wind frequently blew, made it impossible to properly control the interior humidity, and in this connection it might be said that it is always desirable to have the fermenting house so that it can be

tightly closed, thereby controlling the humidity of the interior. In case the humidity should become too low it can be increased by admitting the damp night air. This, however, would rarely be necessary in Porto Rico, because of the usual high humidity of the air. In order to keep a desirable amount of humidity in the air it is advisable to make occasional tests with the hygrometer, and if too much or too little is found means can be taken to secure the proper amount.

Record of temperature in fermenting pile of tobacco.

Date.	Temperature.	Remarks.	Date.	Temperature.	Remarks.
	° C.			° C.	
Mar. 24	28	About 2,000 pounds.	Apr. 18	44	
Mar. 25	?		Apr. 19	45	
Mar. 26	49	Taken down and rebuilt; temperature too high.	Apr. 20	46	
			Apr. 21	50	
Mar. 27	35		Apr. 22	----------	Taken down, rebuilt, and about 3,000 pounds added, thus making a pile of about 9,000 pounds.
Mar. 28	48	Taken down, spread out, and aired, after which it was rebuilt and 1,000 pounds of other tobacco added.	Apr. 23	----------	
			Apr. 24	29	
Mar. 29	----------		Apr. 25	32	
Mar. 30	----------		Apr. 26	35	
Mar. 31	28		Apr. 27	38	
Apr. 1	30		Apr. 28	42	
Apr. 2	35		Apr. 29	43	
Apr. 3	39		Apr. 30	45	
Apr. 4	43		May 1	47	
Apr. 5	46		May 2	49	
Apr. 6	48		May 3	50	
Apr. 7	51		May 4	51	
Apr. 8	48	Taken down, rebuilt, and a similar pile added, thus making a pile of about 6,000 pounds.	May 5	51	Taken down and rebuilt.
			May 7	32	
			May 9	37	
			May 10	40	
Apr. 9	37		May 11	42	
Apr. 10	45	Taken down, rebuilt.	May 12	43	
Apr. 11	----------		May 13	45	
Apr. 12	28		May 14	47	
Apr. 13	30		May 15	48	
Apr. 14	32		May 16	49	
Apr. 15	36		May 17	49	Fermentation completed and sorting begun.
Apr. 16	39				
Apr. 17	42				

SEED SELECTION.

An examination of the tobacco fields of Porto Rico and of the product in the factories and warehouses shows a number of tobacco varieties in the same field or in the same lot of tobacco, so that the crop as a whole can not be spoken of as a distinctive type of Porto Rican tobacco. Among the several varieties noticed two very distinct ones may be mentioned, one in which the veins of the leaf grew almost at right angles to the midrib, and the other (called "lengua vaca")[a] in which the veins made an acute angle with the midrib. These wide variations, which give rise to what may be called different types or varieties of tobacco, are no doubt largely the result of defective methods of seed selection, as pointed out in the report on preliminary investigations. Indeed, the method of procuring tobacco seed is such

[a] Literally "cow tongue"; i. e., a narrow, pointed leaf.

that rational seed selection is thought to be a most important problem for tobacco culture in Porto Rico. Only good seed should be used. The best seed comes from the best plants, and these alone should be chosen for seed production.

The heaviest tobacco seed is usually produced by the largest capsules. In a vitality test made by the United States Department of Agriculture with heavy, medium, and light weight seeds from the same tobacco plant, it was found that 95 to 100 per cent of the heavy ones germinated, 50 to 85 per cent of the medium ones, and 0 to 12 per cent of the light ones. It is important, therefore, to use only the heavy seeds.

As a general rule it is a sign of degeneration when the plants in the seed bed show a scanty growth and when diseases appear in the field, resulting in a diminished yield. This degeneracy is also evidenced in the curing house by variegated colors and spotted leaves and by the rigidity and contraction of the leaves. If these symptoms are present a renewal of the seed, or at least a rigorous selection of the propagating plants, is necessary. Whenever a superior product is obtained from the seed planted everything possible should be done to prevent hybridization and to secure the perpetuation of the variety. It is thus advised, whenever a large number of proper plants for seed purposes are at hand, to get a large quantity of that seed from the crop and to use this seed for following years as long as it keeps its vitality, usually about ten years.

The Connecticut State Agricultural Experiment Station found that the leaf of both broad leaf and Connecticut Habana of favorite strains generally show a tendency to become larger from successive crops of seed; in fact, the leaves are frequently so large that they cut to waste. The same has also been noticed in regard to Porto Rico wrappers, and it is a common fault that after all the wrappers possible have been cut from a leaf which cost the cigarmaker 25 to 75 cents per pound, and even $1 to $3 per pound for shade-grown, there is left too much tobacco which can be used only for scrap, valued at 3 to 6 cents per pound. This, then, is another instance in favor of using from good seed as long as it will retain its vitality, rather than use seed from each succeeding crop.

It must be borne in mind that selection should be made for different purposes, and that a good wrapper leaf has very different characteristics than one required for a filler.

In case of wrapper, a light-colored, thin, elastic, and somewhat round leaf, with small veins, is desirable. The most desirable size is 18 to 20 inches long in the field, which gives leaves 16 to 18 inches long after the shrinkage due to curing, fermenting, and seasoning. The plants should also be early maturing, vigorous, free from disease, and possess a uniform type of leaf from top to bottom, the leaves being close together on the stem.

FIG. 1.—TYPE OF FLORIDA SUMATRA LEAF.

FIG. 3.—TYPE OF CONNECTICUT-HABANA LEAF.

FIG. 2.—GOOD TYPE OF LEAF FOR WRAPPERS.

FIG. 4.—POOR TYPE OF LEAF FOR WRAPPERS.

Plants with the above qualities should not be topped, but left for seed production. All suckers should be removed and only the crown flower stalk left. It is also advisable to remove none of the leaves, as experiments have shown that the greater the number of leaves left on the seed plant the better the quality of seed. Great care should be taken to prevent pollen from neighboring varieties being carried to the selected plants, and consequent crossing of varieties. In case of doubt in this regard it is best to reject the seed. The results of careful seed selection will be very clearly shown on the field the next year. For types of leaves see Plate V, figures 1 to 4.

The Plant Breeding Laboratory of the United States Department of Agriculture has begun selecting and cross-breeding tobacco with reference to improving the leaves, and eighteen selections and crosses in duplicate were sent to the writer to be planted during the winter of 1903–4. One set was planted at Aguas Buenas and the other at Aibonito. At the last-named place the set was destroyed by the "leaf miner," or "split worm," after the plants had been set in the field, so no seeds were secured. (Pl. IV, fig. 4.)

At Aguas Buenas the plants did well. (Pl. IV, fig. 3.) Of each selection the best and most uniform plants were selected and 30 to 40 capsules only left on the main flower stalks. These were covered with manila paper bags to prevent crossing with other plants. Seeds of these selections have been saved for further work along this line. It may be said that as a result of this selection the plants have shown great improvement in uniformity of leaf, and the results are very promising. The most important characteristics of the mother plants were all transmitted in the seed, as was proved by a comparison of each plant with the notes which had been carefully made of the appearance of the mother plant. It is necessary for each tobacco grower to make his own selections in the field, and upon deciding which type or types of plants he wishes to perpetuate to bag such selected plants after the flowering begins.

SUGGESTIONS FOR THE IMPROVEMENT OF PORTO RICAN TOBACCO.

The investigations carried on during the year are not in all respects conclusive. It is recognized that further work is desirable, and it is hoped that such may be continued in the near future.

In tobacco culture, as with any other branch of agriculture, it is recognized that practice must conform to the conditions with which the planter has to contend. However, there are certain general principles that are in all cases applicable. Endeavoring to keep within the bounds of these, the following suggestions are made with reference to improving the methods of growing, curing, and fermenting tobacco in Porto Rico.

To be appreciated by the majority of smokers in the United States it is necessary that tobacco should have perfect combustibility (burning power), an agreeable aroma for the filler, a small quantity of nicotin, light color, and small veins for the wrapper. For the manufacturer, the shape of the leaf, its structure, and elasticity are also of great importance. These qualities are generally not found in thick leaves. It is, therefore, desirable to produce a tobacco which is not gummy, excepting for roll or chewing purposes—i. e., which does not contain a superfluous amount of glutinous juice, or, as it is termed in the local vernacular, "miel" or honey. If gummy it has a disagreeable taste and less combustibility. The smoke of the tobacco must not be acrid or biting, but should be mild and have an agreeable aroma. To obtain the above-mentioned qualities the planters generally sacrifice quantity to quality. This of course can not be advantageously done in countries where the climate does not allow the production of a leaf of very fine aroma, but could be very well applied in Porto Rico, because it has already been proven that Porto Rico has a favorable climate for the production of very good tobacco of fine flavor and aroma.

CHOICE OF LAND.

Before engaging in the business of tobacco growing the planter should ascertain whether he has suitable land for the purpose and, if so, to what class of tobacco it is best adapted. It has already been pointed out that the texture and structure of the soil has a marked influence upon the character of tobacco produced. Soils light in texture—i. e., having a relatively large amount of sand and small amount of clay—are in general best suited to the production of wrapper tobacco, and give leaves of medium size, fine texture, and good color. The filler crop may be grown to better advantage on a heavier soil. The influence of the soil may be partly overcome by climatic conditions and manipulation, and, as pointed out above, by the use of shade and proper methods of handling a high percentage of good wrapper leaf may be produced on a heavy soil. The character of the subsoil is also important. A sandy soil under low rainfall and without irrigation should be underlaid at a depth of 1.5 to 2 feet by a somewhat stiff subsoil, otherwise the plants will suffer from drought. On the contrary, if the rainfall is abundant a very porous subsoil will give best results, because of the drainage which it affords.

A striking example of the influence of the character of the subsoil upon the quality of tobacco may be found by comparing the subsoil of the famous Vuelta Abajo district, in Cuba, with that of the hilly districts of Remedios. In the first instance the subsoil is very sandy and the tobacco has an extremely fine texture and superior aroma, while in the latter case the subsoil is very heavy in texture, contains much organic matter, and the tobacco is much coarser, darker, and stronger. The following table gives the mechanical analyses of these

two subsoils as made by the Bureau of Soils, U. S. Department of Agriculture:

Mechanical analyses of subsoils from two Cuban tobacco districts.

Source of subsoil.	Moisture in dry-air sample.	Organic matter.	Gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Fine silt.	Clay.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Vuelta Abajo district	0.74	3.80	4.06	4.62	8.28	21.67	43.09	6.53	1.82	5.69
Hilly district of Remedios	5.17	10.01	1.31	.36	.52	4.51	14.97	21.24	9.37	32.32

The influence of dew and rainfall upon the taste and aroma of tobacco is very noticeable. The very fine cigarette tobacco produced in Yenidje Karasou (Turkey), which sometimes brings $4 to $5 a pound, is grown on a rather poor soil with stony subsoil. Of rainfall and dew there is but little, and the plants being set out at a distance of only 6 inches, or even less, and no irrigation being applied, the leaves remain small and soft, but possess a superior flavor and aroma. In other parts where the soil is loose and contains more moisture, the roots spread and the plants grow very high. An ample rainfall produces large leaves, but the flavor and aroma are impaired by this rapid growth, and the tobacco produced is light and nearly tasteless. The same can be said of Sumatra tobacco, which, under the influence of the tropical rainfall and very abundant moisture of the air, grows speedily, and being planted very closely and topped high, a cigar made from Sumatra tobacco alone would possess neither aroma nor taste. The value of Sumatra tobacco lies only in its unsurpassed value as wrapper material.

One of the first considerations should be to use care in choosing lands for tobacco growing, and, as has been seen, one class of land should be chosen for growing wrapper tobacco, while another is better suited for growing the filler, keeping always in mind that the treatment given to wrapper and filler must also be quite different from the beginning to the end.

SEED AND SEED BEDS.

The tobacco seed should be secured with reference to the kind of tobacco the land is best suited to grow. The seed should have good vitality, a condition which can be easily tested by placing 100 seeds between two moist blotters and keeping them between two plates a sufficient length of time to allow the seeds to germinate.

The time of preparing the seed beds will depend on when the plants are to be set in the fields. The seed should be sown forty-five to

sixty days earlier, as it requires that time for the young plants to attain the proper size to be transplanted to the fields. For seed beds a fertile soil of medium texture is desirable, and it should be worked into the finest possible condition and freed from all coarse organic matter. The soil should be elevated into beds not more than 3½ feet in width and as long as may be desired. The elevating of the soil prevents rainwater falling on adjacent land from running onto the beds, and the narrow width enables the workmen to reach from either side to the middle of the beds to remove weeds without getting on the soil and compacting it. To prevent washing by rains removable straw or cloth covers should be used until the plants become well established.

FIG. 1.—Types of plants used in transplanting: A, poor type; B, good type.

There is a tendency in Porto Rico to select as much as possible slender seed plants from the seed bed to be set out. These slender young plants (see fig. 1A), however, have a much weaker root development and do not overcome so well the check of transplanting or diseases.

The stocky plants with well-developed root system (see fig. 1B) are believed to be more vigorous, and therefore an attempt should be made, as far as practicable, to produce this kind of young plants in the seed bed.

Lack of light results in a decreased action of the chlorophyll and consequently weakens the assimilation, thus reducing the necessary organic building substances.

In Porto Rico the lack of light and air in the seed bed is largely due to having the seed plants too close together, and therefore the amount of seed sown on a certain surface is of the highest importance. If it is observed that they are rather close together it is always advisable to thin them immediately, thereby giving each plant sufficient space for normal development.

Great care should also be taken to avoid injury to the roots when the plants are removed from the seed bed. To facilitate the pulling

of the young plants it is best first to sprinkle the beds with water. It is desirable to have as much of the fine soil as will adhere to the roots of the plants removed with them.

TIME OF TRANSPLANTING FOR WRAPPER AND FILLER.

In Porto Rico, which is situated between 17° 55′ and 18° 32′ north latitude, the best season for planting tobacco seems to be in the winter, which is also true of Cuba. The rainfall at that season is less and the temperature several degrees cooler than in summer. In the summer, under the influence of greater warmth and moisture, the plants grow more rapidly, but the leaves do not acquire that desirable aroma that they have when grown during the period in which less humidity and plenty of sunshine prevails. When grown in the summer there is also more danger from loss by standing water in the fields and diseases are more prevalent. It is very important to gauge the time of planting so as to avoid excessive rainfall or extreme drought during the growing season and also to have the harvesting and curing period occur in comparatively dry weather.

Generally, the best time for transplanting the wrapper tobacco seems to be about the end of October or beginning of November. This brings the harvest time about February 1, and gives that month and March, which are on the average the driest of the year, for the curing. This also avoids serious damage by the flea-beetle, which is most prevalent during the dry season.

The following table, which gives the mean monthly and annual rainfall for various districts, shows that on the average November is a month of high rainfall, but during the following months of December, January, and February it rapidly decreases. If, therefore, level, poorly drained land is to be used for the wrapper crop, there is danger of the tobacco being damaged and sometimes destroyed by wet weather. In such cases it is advisable to defer the planting until December.

Mean monthly and annual rainfall for various districts in Porto Rico.

Station.	Elevation.	Length of record.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual normal.
	Feet.	*Years.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*
Isabella	243	5	4.74	1.51	2.12	5.58	7.75	6.11	3.49	6.41	4.52	5.68	8.74	6.37	63.02
Utuado	427	2 and 3	[a]4.62	.43	2.80	5.50	11.39	8.44	5.16	6.29	11.48	11.54	11.07	4.93	83.65
Caguas	246	3 and 4	[b]6.02	1.18	3.11	[b]5.82	5.49	10.41	9.83	[b]8.36	5.87	10.63	7.11	[b]3.85	77.68
Cayey	1,247	5	4.11	1.63	2.29	5.04	9.45	9.96	7.56	8.92	6.87	6.63	7.32	4.75	74.53
San Lorenzo	203	4	3.96	1.38	3.64	5.34	8.38	17.49	8.04	9.49	9.07	8.39	7.11	5.53	87.82
Yauco	98	3 and 4	3.37	.55	[b]2.56	3.31	5.28	7.53	7.95	3.61	5.17	4.67	4.68	2.07	50.75

[a] For two years only. [b] For three years only.

For the filler crop it is advised to plant about the middle or close of December, so that the principal growth will be made during the

drier weather of February and March, as the resulting slower growth develops a finer aroma. If two successive crops are to be obtained in the same field it is advisable to transplant early in October, so that harvesting can be done in January. The field is then plowed, fertilized, and harrowed, so as to have the second planting done at the end of January or beginning of February. In this case irrigation would be necessary. This second planting is very frequently practiced in Cuba with very good results.

METHOD OF TRANSPLANTING.

The seed beds should be thoroughly wet before attempting to remove the plants, in order that they may be removed with the least possible injury to the roots. The young plants should be covered with plantain leaves or a wet cloth during their transit to the field, and in the process of planting the roots should be exposed to the sun as little as possible. A few minutes' exposure of the roots to a bright sun is often sufficient to kill the plant. The plants should be placed in the holes with the roots straight and moist soil pressed firmly around them and hilled up to the leaves, the lower ones having been removed. It is well, as far as possible, to do the planting on cloudy days or mornings and evenings, thus avoiding the hot sun of the middle of the day, which is responsible for the death of many plants when the work is done at that time. The necessity of resetting many plants makes the fields uneven and causes inequality in time of maturing. As a result, half-ripe, ripe, and overripe leaves are cut at the same time.

CULTIVATION.

Careful and thorough cultivation should be given the tobacco fields during the early growth of the plants. During dry weather the surface of the soil should be frequently stirred in order to destroy capillarity, thereby reducing evaporation directly from the soil and conserving soil moisture for the use of the plants. Any dry blanket that can be placed between atmosphere and the damp soil will check this evaporation. The most practical protection is a covering of finely pulverized dry soil 2 or 3 inches deep. Surface cultivation not only reduces the loss of water from the soil, but also prevents an accumulation of the soluble plant food immediately at the surface and where it is out of reach of the plant roots. Cultivation should not be too deep, especially near the plants, as it destroys many of the small roots, thus lessening the feeding power of the plant. It also facilitates the formation of nitrates. Cultivation should not be undertaken when the soil is too wet, because stirring the soil when in such a condition gives to it a bad physical condition. If wet weather is continuous, all weeds should be removed with as little cultivation as possible. During the process of cultivation the soil should gradually

be worked toward the plants, thus hilling them up and preventing their being blown down by winds.

TOPPING.

For wrapper purposes it is advisable to top high. This is especially true when abundant sunshine and favorable conditions prevail during the growing season. If, however, the weather is cloudy and rainy, the topping should be done somewhat lower and a smaller number of leaves left on the plants. This is especially true in case of shade-grown tobacco, as the shade has a tendency to still further increase the humid conditions to which the fields are subjected. Weak plants ought to be topped lower than strong, well-developed plants, which will be able to mature a larger number of leaves. Too high topping makes leaves deficient in elasticity; too low topping, too heavy leaves. Experience is necessary in order to top the plants just right, taking into account weather conditions and type of plants and soil.

Suckers immediately appear after the topping, and these should be removed at frequent intervals. Experience has taught that instead of breaking off the suckers in the axil it is better to leave a small part of the stem of the sucker, about 1 inch in length. By so doing less suckers will reappear. The removal of the suckers throws the strength of the plant into the leaves, but if there is a tendency, through having topped the plants too low or through change in weather conditions, for the leaves of the plant to become too thick, this may be counteracted by leaving one or two suckers on the plant.

HARVESTING.

Two methods of harvesting are in use. One consists in removing each leaf from the plant at the most favorable stage of ripeness and the other is to cut the whole plant when the largest number of leaves are in a favorable stage of ripeness. The first method should always be used for wrapper or high-grade tobacco, as it gives more favorable results. Great care should be exercised to prime the leaves at the most favorable stage of ripeness, taking first the bottom leaves, then successively the middle and top leaves, with a few days between. The proper time to harvest is determined by the appearance of the leaves, and an experienced eye is required to detect the minute differences which mark the leaves when in the most favorable degree of ripeness.

Overripe leaves become less combustible, are less elastic, give darker colors, and contain more nicotin, all of which is undesirable. In unripe leaves the colors are difficult to change in the curing process, and often turn from green to black in the fermenting pile. After priming the leaves should be transported to the curing shed in baskets provided with burlap for covering the tops and sides, so as to protect the leaves from dust and direct rays of the sun.

With the cut system of harvesting it is advisable to cut the plants when the middle leaves show maturity—for wrapper purposes early in this stage and for filler a little later. The plants should be allowed to lie on the ground for a few hours until wilted, after which they are transported to the curing shed. It is sometimes advisable to string the plants on poles before transporting, and upon arrival at the shed the poles with plants on them are put in place without further handling of the plants. These short poles or laths should be of proper length to fit the compartments of the shed, the plants being fastened by means of a cord looped around the plant stems and passing from side to side, so that the plants alternate on opposite sides of the pole. The poles with plants attached may be transported to the sheds suspended on two long poles carried by two men or on a wagon prepared for the purpose.

CURING SHED.

For a good curing shed five points should be considered:

(1) Orientation or direction, (2) situation, (3) dimensions, (4) construction, and (5) aeration or ventilation.

The orientation of shed should usually be northeast by southwest, because in Porto Rico the prevailing wind is from the northeast. Where the direction of prevailing wind is different the orientation should conform. The shed should be so built that when the ventilators are open the wind will not blow directly in at the openings. When wind blows directly in at ventilators the near-by tobacco dries too rapidly and the leaves remain green instead of changing to desirable colors.

The situation of the curing shed depends upon the requirements of the farm, but, other things being equal, should be convenient to the tobacco field, and should be as much as possible sheltered by other buildings or trees on the side from whence the wind comes. Close proximity to marshes, streams, or wet land should be avoided, because the dampness from such sources is conducive to molds and pole-sweat.

The dimensions of the curing shed will depend upon the size of the crop, but the width should never be too great for good ventilation of all parts of the interior when filled with tobacco. The width should not exceed 30 feet, and the height should be nearly equal to the width, while the length may be as great as desired.

The construction of the curing shed will depend to a certain extent upon the available and most economical material for the structure. In Porto Rico, as a rule, the framework may be made of poles cut from native trees. Inch boards of either native or imported lumber will probably be most desirable and economical for the sides, while thatched roofs, either of palm leaves or grass, are suitable. Thatched roofs favor a more equable temperature than either board

or metal ones. It is most important that the shed should be so constructed that the temperature and humidity can be controlled. In order to accomplish this it should be sufficiently tight to prevent air currents when closed. The ventilators should be at frequent intervals and sufficiently large to secure any desired amount of ventilation. They should be so constructed that they open against the wind, can be fastened to any sized opening, and can be quickly and tightly closed. The interior framework should be so constructed with poles and cross poles that the whole space can be utilized for hanging tobacco. Strong wires may be tightly stretched and take the place of the smallest poles. Poles sufficiently strong to support movable planks on which the workmen stand should be placed at intervals sufficiently close to enable all parts of the space to be easily reached. The sticks on which the tobacco is strung may consist of ordinary lath $\frac{1}{2}$ by $1\frac{1}{2}$ inches, by 4 feet long, with a saw notch in each end to hold the cord, or they may consist of small native saplings of any desired length.

Two kinds of aeration or ventilation are recognized—one slow and continuous, the other rapid and periodic. The first is acquired by opening the small ventilators at the bottom and top of side walls or by opening the large ventilators only slightly. The rapid ventilation is effected by opening the large ventilators as wide as possible, always guarding against the direct entrance of wind or sunshine. Large ventilators may consist of ordinary doors extending from the ground to the eaves and hinged at the side, or the same form of door may be hinged at the top and open from the bottom. Another form consists in having the side boards of the shed horizontal and have every other one or every third one hinged at the upper edge. These may all be opened to any desired width and a uniform ventilation of any desired volume given to all parts of the shed, or the top and bottom one only may be opened, giving a slow ventilation.

CURING.

The filling of a curing shed should be concluded as rapidly as possible and the shed closed for the curing process, so that the tobacco in all parts will require as far as possible the same time and ventilation. For this reason it is advisable to limit the size of curing sheds.

During the early period the curing should be effected by a slow and continuous ventilation. After the colors are obtained the ventilation may become rapid and periodic. During very hot days the sheds should be kept closed and opened during the following night. After excessively damp weather it is also well to give more rapid ventilation on a dry day to drive away the excess of moisture and prevent molding. If damp weather continues for several days it becomes necessary to build fires in the sheds. Charcoal is preferable to wood for this purpose, because it produces less smoke. Care must

be taken that the tobacco does not turn black for lack of sufficient air, reduction instead of oxidation taking place.

The nature of the processes which take place in the curing of tobacco have not yet been fully worked out, but in a general way there is a loss of water—about 80 per cent of the green weight of the leaves—and a modification of the chlorophyll and other compounds of the leaf and the resulting change in color from green to yellow, then to red and brown.

If the leaves are cured in a current of hot air the water is quickly lost and the color remains green, because sufficient time has not been allowed for the biological processes which cause the color changes to take place. If the leaves remain longer in the hot-air current they may also lose their fermenting power. Even after restoration of the excessive loss of water only a slight fermentation can be produced.

In order to facilitate the transformation of the matter in the leaves a slow curing is necessary. If, however, the circulation of air is too limited or stopped, reduction takes place and the leaves become spotted and, if no ventilation is given, very soon turn entirely black and lose their resistance and elasticity and finally become worthless.[a]

Specific rules for the curing of tobacco can not be given, for much depends on the weather conditions and the character of the crop and shed. In a general way ventilation should be slow, with a constant circulation of air around all of the leaves until the parenchyma changes color. Rapid ventilation should be avoided during the early stages of curing, except for short periods after very damp spells, which may be resorted to in order to drive out the excess of moisture. High temperature and excessive humidity must be avoided.

The time of curing usually ranges from twenty-five to thirty-five days. The process should cease when suitable color is obtained, bearing in mind that the colors are modified to a certain extent in the process of fermenting. When the curing is completed it is well to close the ventilators during the day and open them wide at night, in order to bring the tobacco into a moist condition before removing it from the poles. None should be removed until the reduction of the midrib is complete. If the curing has been slow and the conditions favorable, the colors at the time of removing from the poles should be fairly uniform. It is advisable, however, upon taking down the tobacco to immediately put it into small piles, which favors uniform fermentation and also further increases the uniformity of color. In no case should tobacco be allowed to remain in the curing shed very long after it has been completely cured.

The curing of the whole plant is effected with nearly as good results

[a] The writer noticed in Porto Rico as well as in Cuba cigars of which the wrapper was covered with black spots. It is thought that this was caused by the lack of ventilation at certain periods while tobacco is in the shed.

as regards color as in case of the primed leaves. The chief difficulty is that the top leaves, the less ripe, are covered by the middle ones, and these in turn by the bottom ones, so that the ripest leaves are the ones which, on account of their exposure, receive the greatest ventilation while the greenest ones receive the least. This difference is probably partly overcome by the leaves being connected to the stalk and through a possible movement of water from the greener to the riper leaves. The advantage in case of the primed leaves is that those of equal ripeness may be placed separate from those which may be greener and, therefore, given a different ventilation.

The system of cutting and curing the whole plant, however, is the cheaper, and is advised for crops that do not promise a considerable percentage of wrapper leaves. When the cut plants are removed from the poles they should not be placed in piles, but the leaves should at once be removed and the top, middle, and bottom ones kept separate. Further sorting of the leaves need not be made at this time, but they should be made into hands and at once put into small piles. These piles should be frequently inspected to see that the temperature does not materially rise. If the leaves are too moist and begin to heat, the piles are separated and after a little exposure are made into piles again. When this operation has been repeated several times several small piles may be put together. It is of course understood that before this work is commenced the plants should be moistened by leaving the ventilators open during the night preceding the operations, and in case of a dry day the work should cease before the plants become too dry to handle.

SUGGESTIONS REGARDING FERMENTATION.

In order that tobacco may properly ferment it is necessary that the requisite amount of moisture and ferments be present in the leaves. The process of fermentation develops color, gloss, elasticity, burn, and aroma. It is most important that the leaves contain the proper amount of moisture. If too dry the fermentation progresses very slowly or not at all; if too wet it progresses very rapidly and there is danger of molds and putrefaction. The operation requires very careful watching by one who has had previous experience.

Under the old régime, when dark colors were used, fermentation was allowed to progress very rapidly, the high temperatures producing the dark colors. It was then sufficient to carefully watch the temperatures and to prevent only such high elevations as might burn the leaves. At the present time, with the demand chiefly for light colors, it is necessary that fermentation progress slowly. This can be accomplished by slightly less moisture in the leaves, and by repeatedly tearing down and rebuilding the fermenting piles whenever the temperature rises to 50° C.

In order to ascertain the temperature of the piles bamboo, wooden, or metal tubes are placed in the piles when they are built, one end being at the center of the pile and the other reaching to the circumference. If the piles are large two or three of these tubes may be used, one near the bottom, one near the middle, and another near the top. Ordinary chemical thermometers are inserted into the tubes and may be quickly removed and read at any time. The outer ends of the tubes should be closed with corks or cotton to prevent cooling of the interior.

Before fermenting the tobacco should be roughly graded into wrappers and fillers. The tobacco should then be tied into hands and built into piles by laying the hands straight and even, with butts to the outside. The size of the piles may vary according to the amount of tobacco in hand. It is difficult, however, to successfully ferment a small quantity, and the operation should not be undertaken with amounts less than 1,000 pounds. A convenient size for the fermenting piles is 5 to 6 feet wide, 10 to 12 feet long, and 4 to 8 feet high. In building the pile it is advisable to start the bottom with trash or some noncommercial stuff, because the bottom usually ferments very slowly. Excessive pressure should be avoided in the early stages, and the hands be simply laid on the pile from the outside and gently pressed. Piles built in this way settle considerably, so that after twenty-four hours more tobacco may be put on if thought desirable. When completed it is advisable to cover the piles with burlap in order to protect them from drying out. As regards the further care of the piles the following directions are taken from Farmers' Bulletin No. 60, United States Department of Agriculture:

> The bulk is watched very closely, and as the temperature rises it is torn down, each hand of tobacco is taken up and shaken thoroughly to dry it a little, to cool it slightly, and to open the leaves so that they will not stick together. Before the sweat is completed the bulk is pulled down and built up eight or ten times, according to the condition of the tobacco. It is impossible, even for an expert curer, to give explicit directions as to when the bulk should be turned, as it depends entirely upon the condition of the tobacco and the temperature it attains, and these must be determined by the operator.
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> The temperature must rise gradually, and if it is found to be rising too rapidly the bulk is torn down and a fresh one built up. Sometimes the bulk is not up over twenty-four hours before it is torn down again and built up afresh. If the tobacco is in high case, that is, quite moist, the bulks have to be turned over frequently in order to prevent too rapid action and to shake out the leaves which would otherwise stick together. If a bulk, as seldom happens, should dry out, it is turned over and mixed with a bulk which is in high case. The tobacco should never be sprinkled in this stage of the process to bring it into case.
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> The temperature of the pile is allowed to rise gradually until it occasionally reaches 180° F. The fermentation is then at its highest. From this point the temperature subsides until the fermentation is complete and the bulk attains the normal temperature of the room. This maximum temperature must not be reached too quickly, and it must be managed differently with the different tobaccos.

The fermentation must be carefully controlled and not allowed to go too far with the wrapper leaf. With the filler, the further it goes and the more intense the action the stronger and finer will the tobacco be for its purpose, if the work is judiciously done. As a matter of fact, it is not unusual to resweat the filler leaf to bring out the strong, rich properties which it is desired to develop. As the fermentation does not extend to the bottom of the pile, it is customary to put 8 or 10 inches of trash, which has already been sweated, on the bottom; and where bins are used a layer of trash is also put around the sides.

The above maximum temperature of 180° F., which equals 82° C., should be reduced to a temperature of about 50° to 55° C. for tobacco in Porto Rico.

Bottom, middle, and top leaves should be fermented in separate piles.

Bottom leaves require a lower maximum temperature than middle and top leaves. When the top leaves are to be used for filler purposes the maximum temperature may be increased from 5° to 10° C.

The moisture content of the tobacco may be easily ascertained by taking a few representative hands from the pile, weighing them, then drying them in a hot-air bath at 212° F. for about two hours, and again weighing them. The loss in weight divided by the dry weight equals the percentage of moisture in the leaves.

The optimum amount of moisture for fermenting either wrapper or filler has not yet been determined for Porto Rico. In Florida certain experiments have shown that 23 to 24 per cent was favorable. If the temperature rises 14° to 18° F. in the first day it indicates that the tobacco is too moist and contains approximately 27 per cent. With 20 per cent of moisture the temperature rises much slower, and the slow rise in temperature indicates too small a percentage of moisture. With only 20 per cent of moisture it was found difficult to handle and ferment the tobacco.

The fermenting house should not be so high as the curing shed and should have windows sufficient only for lighting the interior. Air currents should be avoided and the floors should be dry. Floors of wood are therefore preferable, and it is often desirable to use mats beneath the fermenting piles.

The tobacco piles may be rectangular or elliptical in shape, and the height of them will depend upon the quality of the tobacco. That of superior quality should at first be fermented in piles about 2 feet in height; medium quality in piles 3 to 4 feet in height, while large piles of inferior quality and trash may be 6 feet or more in height. The good and medium piles should be covered with burlaps or mats to prevent loss of moisture from the outside and thereby facilitate a more even temperature throughout the pile. By degrees, as the tobacco becomes drier, larger piles are made by putting two or more small piles together, in order to obtain higher temperatures. In rebuilding the piles care should be taken to avoid returning tobacco

to the same position in the new pile that it occupied in the former one. It is necessary that all the hands be placed at least once in the center of the pile. In making the successive piles larger and more compact the maximum temperature is gradually increased from about 35° C. in the first piles to about 55° C. in the last ones. The increase in temperature must be very gradual, otherwise the quality of the tobacco is depreciated. In case of molds, which result from the tobacco being too moist, it is necessary to thoroughly ventilate the tobacco and brush the leaves. Where the sweating is done slowly to keep the color light, it is well to allow the tobacco to stand some time in the bulk or bale to age. This aging is especially desirable with filler leaf, so as to develop the aroma.

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